Building the Opencockpits Transponder

With this tutorial I hope to partly address the lack of adequate instruction available for assembly of the Opencockpits radios. This is a shame as the Opencockpits hardware and software offer some of the best value for the home cockpit builder on a budget. There are a number of websites that proved invaluable to my knowledge and understanding of Opencockpits hardware and software and I would highly recommend researching these sites prior to undertaking this build. You'll find a full list at the end of this document.

This tutorial assumes that the user already owns the Opencockpits Mastercard as the associated 7-segment Display cards need to connect to this unit in order to operate. You should also have an understanding of the software SIOC which is used to program the different functions of the radios. A sample file is included in the Appendix.

The XPDR panel comprises a front plate laser cut and ready for backlighting, backplate, switch mounting plate and IDENT button.

In addition you will need the following to complete the XPDR:

- 1 x OMROM B3F 4050 keyswitches
- 2 x ON-OFF toggle switches
- 4 x 7-segment display digits
- 2 x CTS288 rotary encoder
- 1 x Rotary switch (12 position,1 cct)
- 1 x PCB's for 5 digit display
- 3 x Gray knob
- 1 x Opencockpits Display Card
- Lots of multipin plugs and cables

NOTE: The 7-segment displays need to be the Common Cathode variety and all are available from the Opencockpits Shop

Other options you might consider are:

- Dual concentric rotary encoders to provide selection of individual digits.

- 3mm White LED's for backlighting. (Installation details at the end of this document)

The Ident button comes in two pieces. Simply glue the black button onto the clear base with superglue. The backing plate is clear to allow light through when backlit.

Edges need to be painted black to avoid light leakage when backlit. Use acrylic paint available from any craft shop.

Then some sort of pins need to be installed that will push on the switch mounted above it. I used plastic knitting needles cut to size and glued in place. Be sure to get the length correct. The pointed ends insert into the small hole in the Omron momentary switch for button centering.
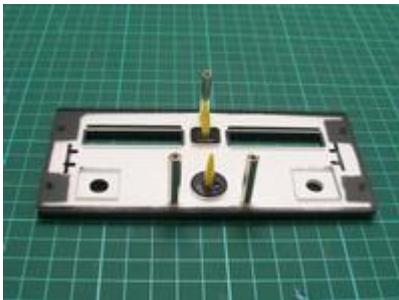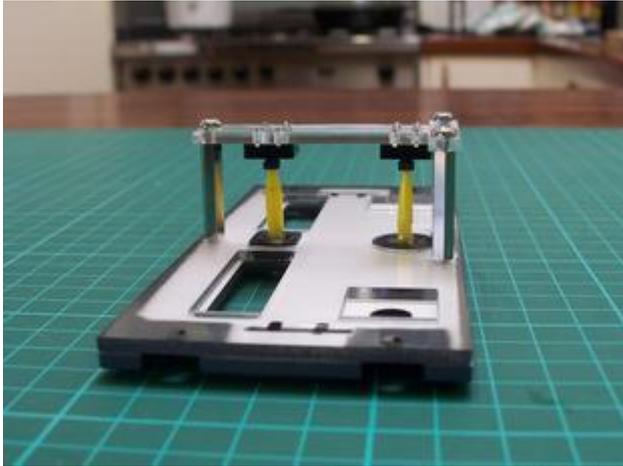

Buttons fit into the backplate and 25mm threaded standoff shafts hold the frontplate to the back and the switches above the buttons as can be seen in the next photo.

These photos show the COMM panel but the principle is the same.

Glue the Omron switches onto the clear mounting plate and align with the needle ends.
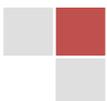
Here you can clearly see how the needle ends insert into the switches and stop them flailing about.

Encoders come with long shafts that need to be cutdown. Measure the required length which will depend on your choice of knob.

Cut with a hacksaw.

Note that these encoders available from Opencockpits incorporate a pushbutton switch. The 3 top legs are for the encoder (known as "A", "C" & "B" legs) and the 2 bottom legs are for the pushbutton. The outer "A" & "B" legs of the encoder connect to two **consecutive** inputs of the Mastercard and the centre "C" leg connects to the corresponding Ground.

To install the toggle switches for both the ADF and XPDR I made an extra backing plate from 3mm acrylic. Drill 2 holes big enough for the toggle necks to fit through and bolt them in place.

The neck of the switches should fit neatly into the holes already drilled in the supplied panel backplate. Glue the switch plates onto the backplate with hot glue. Any cabling can be soldered directly onto the rear switch terminals.

The completed hardware installation.

Now onto the heart of the system, the displays board. The Opencockpits display board controls up to 16 x 7-segment displays connected as shown in this diagram. The displays PCB caters for all the associated connections to the card via multipin cables that you will need to make.

More on that later.

As you can see from the picture above, the 7-segments of each display PCB connects to the board via a 7pin connector and you may have to connect several 7 pin connectors to one board. Some use splitter cables but I decided to take a pcb approach and solder a mulitpin board to the card using strip veroboard.

The Common Cathodes connect to the pins numbered 0 – 15.

Only takes a few minutes and provides easier multipin connection.

Standard pcb pins were used but due to the need to push them through from the underside I modified them by pushing the plastic support down to the base of the pins.

Here you can see the rows of pins inserted from the underside of the veroboard.
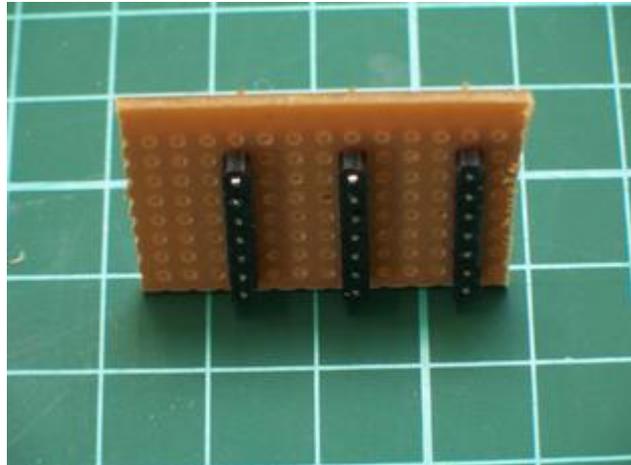
Now onto the construction of the 7-segment displays. Again always use the mounting PCB's. They only cost a few dollars each and make it a breeze to install.

This photo shows the COMM panel but the principle is the same.
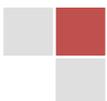
Place the displays onto the PCB's then mount the backplate over the displays prior to soldering. Turn the whole lot over and solder the displays onto the PCB's while mounted in the backplate. This will allow the displays to more easily insert through the backplate later on during final assembly. These backplates are laser cut to very fine tolerance and if you solder without doing this you'll end up needing to file the backplate holes to fit the displays. (Ask me how I know this!)

This is the rear of the 4 digit XPDR display PCB (including the backlighting LED's).

For the XPDR, use a 5 digit PCB and leave one slot empty (the slot furthest away from the 4 pin common cathode connector). Don't cut the board as you will sever one of the 7 segment connections and have to provide a connection wire to compensate as you can see in this photo (blue wire). There's plenty of room to house the full 5 digit board.
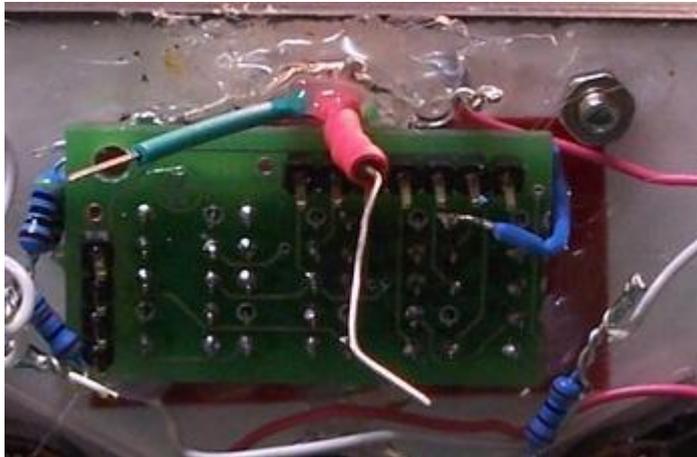

NOTE: You will only need to solder pins 2(f), 3(g), 4(e), 5(d), 6(GND), 8(c), 9(b), 10(a). Pin 7 is the decimal point and will need a separate wire connecting to a Mastercard output. Pin 1 can be left unsoldered as it's just another Ground pin.
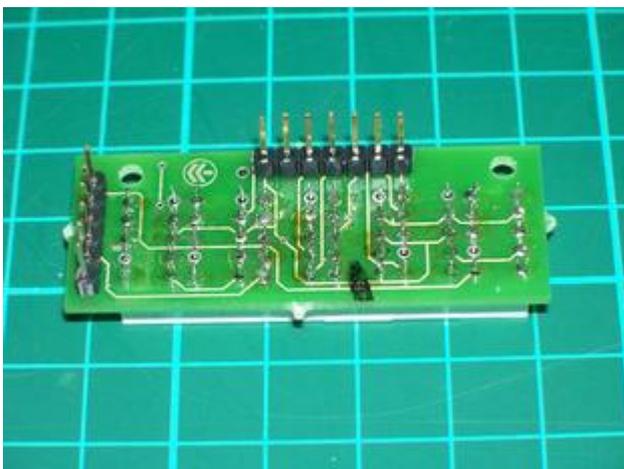
Solder connection pins onto the rear of the PCB to provide multipin connectors. The top row of 7 pins are for the 7 segments of each display (a,b,c,d,e,f,g,GND) and the 6 pins to the left are for the common cathode of each display. In this case there are 6. The 5 display PCB will have 5 pins and the 3 display PCB has 3. Clever hey!

Make sure you place the 7-segs onto the front of the PCB and solder to the rear. The front is indicated by the Opencockpits logo and writing.

Secure your completed displays PCB's onto your panel with hot glue at each corner.
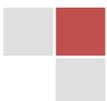
Your next major work is making up cables to connect your displays to your boards. I highly recommend making up multipin connectors. Don't try soldering directly to the display pins. Whatever method you end up using you will have a lot of pin connections to make, it's unavoidable!!

As you can see the 7-segment cables can be paralleled together but the Cathode connections need separate cables to connect to their respective pins on the display board. One ADF radio consists of 10 digits so you'll need one display board.

See Appendix 1 for the circuit diagram of my complete pedestal.

NOTE: If you intend building multiple units as I did you will need to decide which displays connect to which board, remembering there is a maximum of 16 displays per board. This will dictate how many cables you'll need and how many 7-segment cables can be paralleled together. The cable lengths will also be dependent upon where your display boards are located in relation to the radio, but I would strongly advise making them longer than expected to allow for ease of access. If you end up building a complete pedestal setup you'll have a lot of cables to contend with.

The digital displays look more aesthetically appealing with a coloured lens over them. I used standard red cellophane sandwiched between the front and back plates and it works well.

The only criticism I have is that it's a little flimsy and prone to tearing but if you take care it is very cheap and easy and quite effective.

Cut two strips about 50mm x 100mm.

And fold into 3.

Use very thin double sided tape to stick the cellophane in place. You should be able to get this tape at office stationary stores. Don't use the foam style double sided mounting tape, it's far too thick.

Note: This shows the Nav panel but the principle is exactly the same for all panels.

And here is the result. One advantage of cellophane is that it is very thin and doesn't provide too much bulk between the front and back plates.
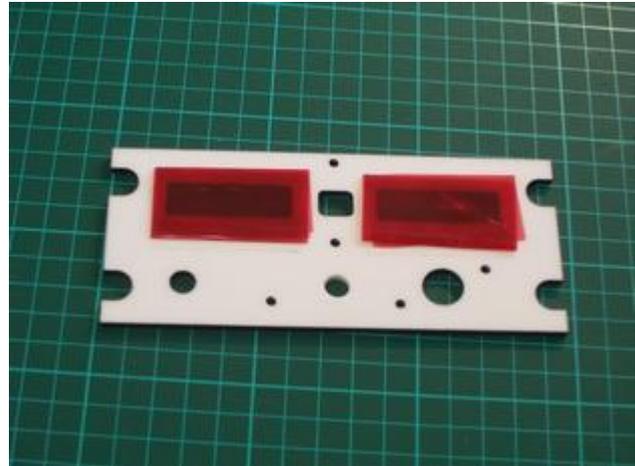
Here's an example of the final wiring mess for the full set of radios in the pedestal. It's really important therefore to take care making up cables to the length required and keeping good records of connections.

BACKLIGHTING

You may already have a preference for backlighting but I found after my own research and testing that I preferred the whiter glow and lower current draw of LED's. I used 3mm White LED's with a brightness of 15000mcd purchased on ebay from China. These are VERY bright and I could easily have gone for a lower brightness, therefore I would recommend something around 10000mcd. You can even go for the warm white variety if you prefer the warmer look similar to incandescent globes. There's nothing fancy about this method and therefore it can be applied simply and cheaply by anyone with the most meagre of skills.


I'm driving my backlighting from a 12v DC power supply and connecting them in a series configuration. The maximum number of these LED's that can be driven from 12v in series is 3, so most of my LED's are grouped this way along with a resistor. These LED's have a working voltage of 3.4v and current draw of 20mA which results in a resistor requirement of 100 ohms per 3 LED's.

NOTE: Take a look at http://led.linear1.org/led.wiz for a very useful LED array resistor calculator. Also be sure to connect the LED's with the correct polarity i.e. -ve leg of one LED to the +ve leg of the next and so on. The resistor can be connected to either the -ve or +ve end of the array but for convention stick with one end throughout your arrays. I connected my resistors to the –ve end of all arrays.

Drill 3mm holes in the backplate to mount the LED's. Use the front plate as a guide to mark the position of the holes depending on where the writing is that you want to backlight.

Again I'm using the Nav panel to demonstrate but the principle is the same for all panels only the hole locations will differ.
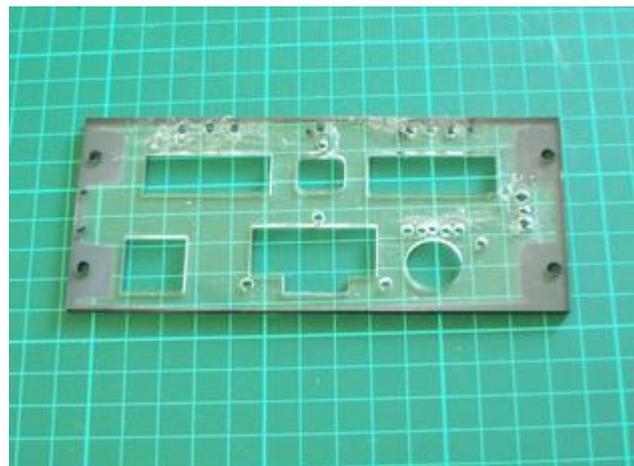
Place the LED's in the holes and adjust for correct placement then use hot glue to hold them in place. Try to group −ve and +ve ends in close proximity as it will be easier to connect them together later.
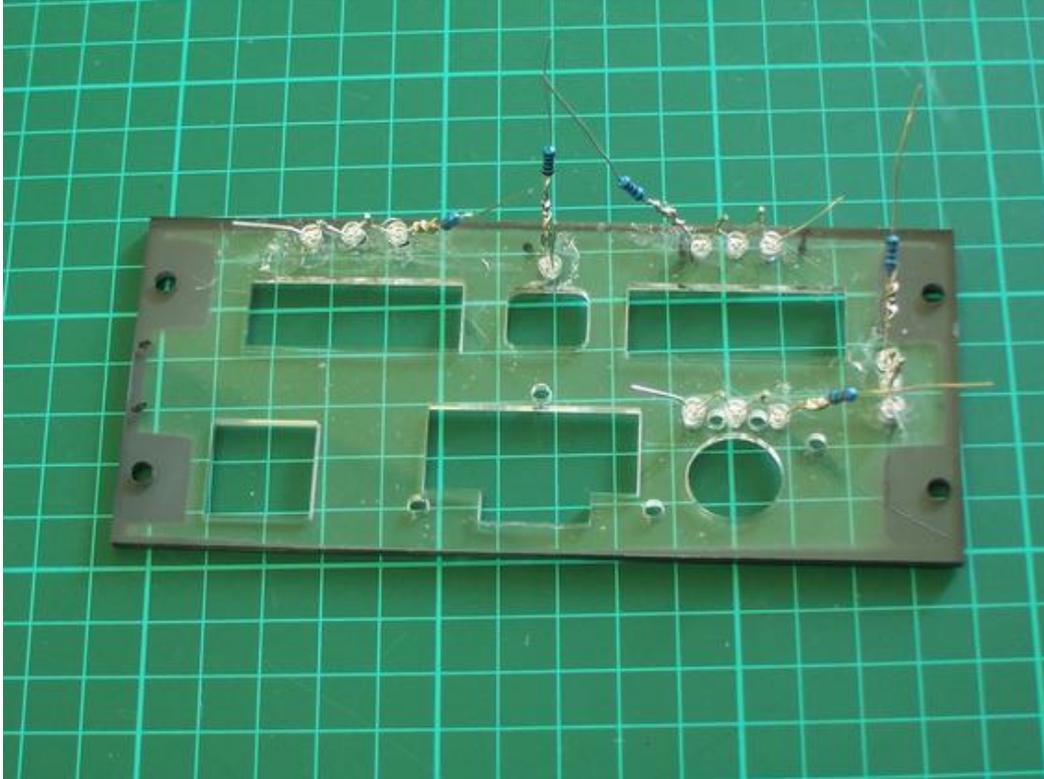
Use heatshrink to protect resistor legs and other wires that you don't want contacting.
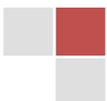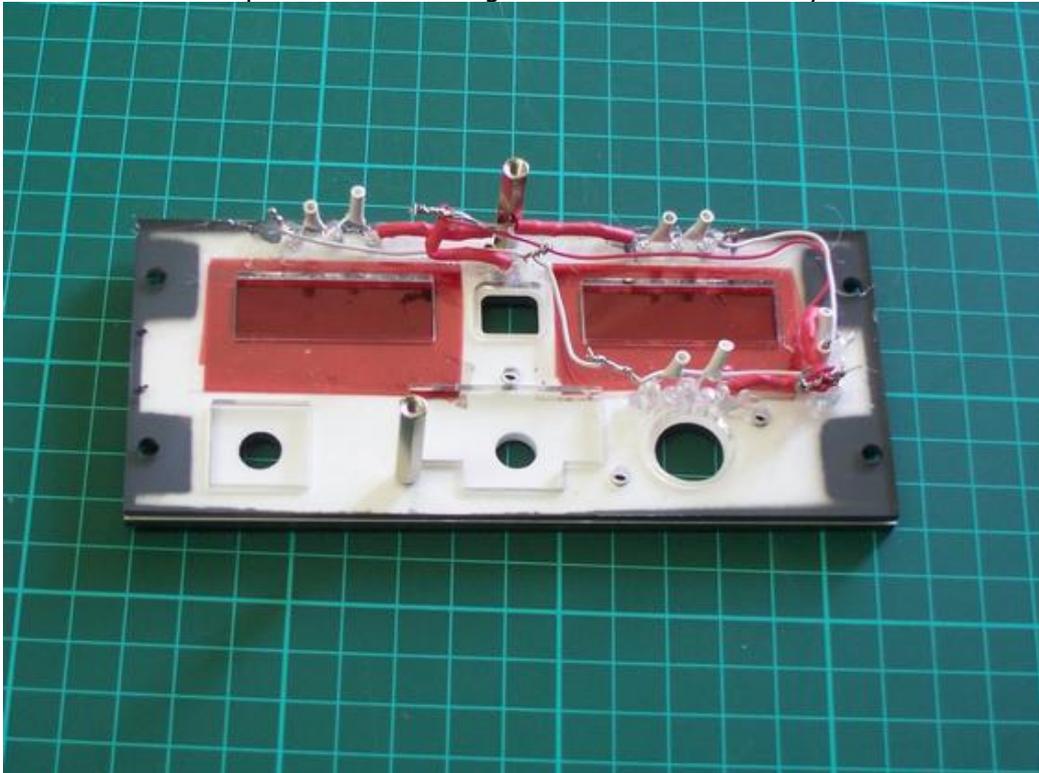
Now join all -ve ends of each LED group together and all +ve ends. Your 12v supply connects to the respective -ve & +ve legs of the completed circuit. I used a piece of strip veroboard and PCB pins to connect my power supply to.

And here is the result. Not bad hey?

This process of backlighting should take approximately 1 hour per panel from start to finish.

The final process of getting the radio working is programming the operations in SIOC. I'm not going into detail here about this process but I would point you to Nico Kaan's website at http://www.lekseecon.nl/sioc.html for an explanation of this very powerful software. You can also download examples of code to adapt and use for your radio.

Appendix 2 contains a working file for this transponder.

Weblinks List:

- http://www.opencockpits.com/catalog/index.php

- http://www.opencockpits.com/

- http://personales.ya.com/micabina737/indexi.htm.

- http://www.lekseecon.nl/

- http://led.linear1.org/led.wiz

For more detailed photos used in this guide, go to my website at http://www.kennair.com.au/avionics.html.

Ken Brand.

DISCLAIMER: Please use the instructions in this tutorial at your own risk. The author claims no responsibility for hardware or electrical damage as a result. This tutorial is made available as a guide only and represents the process, views and opinions of the author and not of Opencockpits or any affiliates.

Appendix 1.

16 Display outputs

STANDBY

6 pin

cathodes

COMM 1

ACTIVE

0

DISPLAYS

BOARD 1

15

7-Segments

40 Pin Connector

4 pin

cathodes

XPNDR

12 Display outputs

STANDBY

6 pin

cathodes

COMM 2

ACTIVE

0

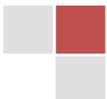DISPLAYS

BOARD 2

15

7-Segments

40 Pin Connector
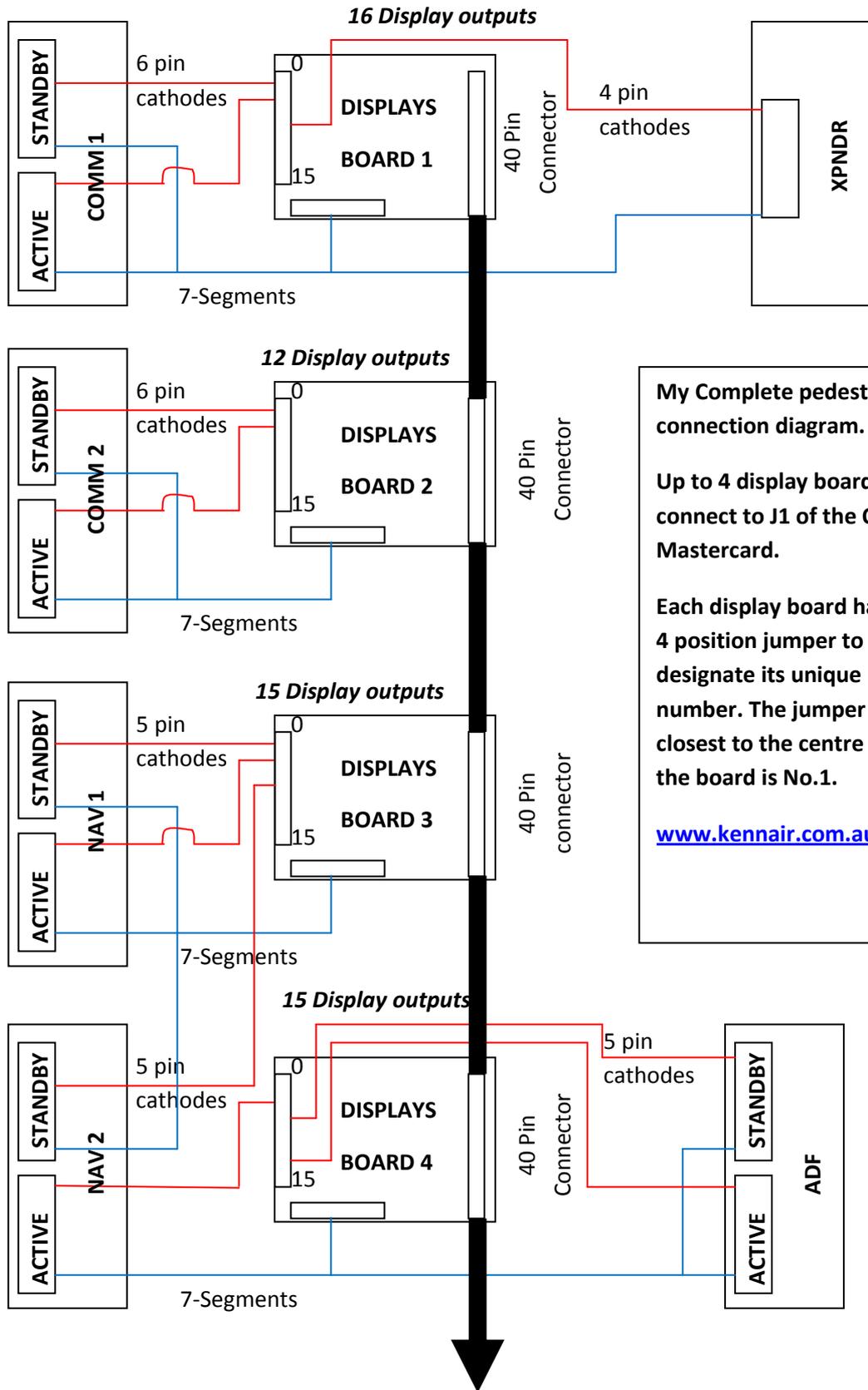
My Complete pedestal connection diagram.

Up to 4 display boards connect to J1 of the OC Mastercard.

Each display board has a 4 position jumper to designate its unique number. The jumper closest to the centre of the board is No.1.

www.kennair.com.au

15 Display outputs

STANDBY

5 pin

cathodes

NAV 1

ACTIVE

0

DISPLAYS

BOARD 3

15

7-Segments

40 Pin connector

15 Display outputs

STANDBY

5 pin

cathodes

NAV 2

ACTIVE

0

DISPLAYS

BOARD 4

15

7-Segments

40 Pin Connector

5 pin

cathodes

STANDBY

ADF

ACTIVE

40 Pin Connector to J1 of Opencockpits Mastercard

Appendix 2.

This is a transponder file sourced from the Opencockpits forum and works with this radio build. Copy this text into a Notepad file, change the input/output and display digit numbering to comply with your hardware and import into SIOC.

```
// *************************************************************************
// * Config_SIOC ver 1.98  -   By Manolo Vélez  -   www.opencockpits.com
// *************************************************************************
//
// ** Transponder using 2 rotary encoders
// ** 1 for High digits and 1 for Low
// ** Sourced from the Opencockpits Forum website
//

Var 0121, Value 12 // High digits
{
CALL &XPNDRCALC
}

Var 0122, Value 0 // Low digits
{
CALL &XPNDRCALC
}

Var 0125, name INPXPNDRHigh, Link IOCARD_ENCODER, Input 2, Aceleration 0, Type 2 // Input High
{
L0 = &INPXPNDRHigh * 1 // -1 will change direction of rotation
V0121 = V0121 + L0
V0121 = ROTATE 0 ,77 ,L0
}

Var 0126, name INPXPNDRLow, Link IOCARD_ENCODER, Input 0, Aceleration 0, Type 2 // Input Low
{
L0 = &INPXPNDRLow * 1 // -1 will change direction of rotation
V0122 = V0122 + L0
V0122 = ROTATE 0 ,77 ,L0 // numbers will range from 0 to 77 then back to 0
}

Var 0129, Link IOCARD_SW, Input 63 // VFR button
{
&XPNDRDISP = 1200 // VFR Code (CH 7000, USA 1200, Germany 0021)
&XPNDRTOFS = TOBCD &XPNDRDISP
}

Var 0130, name XPNDRDISP, Link IOCARD_DISPLAY, Digit 28, Numbers 4 // Display
{
L0 = &XPNDRDISP
}

Var 0131, name XPNDRTOFS, Link FSUIPC_INOUT, Offset $0354, Length 2 // XPNDR
{
L0 = &XPNDRDISP
}

Var 0132, name XPNDRIN, Value 7000 // XPNDR Input from FS

Var 0133, Link FSUIPC_OUT, Offset $7b93, Length 4 // IDT button for Squawkbox

Var 0134, Link IOCARD_SW, Input 7 // IDT button
{
V0133 = V0134
}
```

```
Var 0138, name XPNDRCALC, Link SUBRUTINE // Code calculation
{
L0 = V0121 * 100
L1 = V0122 + L0
&XPNDRTOFS = TOBCD L0
&XPNDRDISP = L0
}
```